

CLAIMS

What is claimed is:

1. A catalytic combustion device comprising:

a first section that receives an oxidant feed stream and a first portion of an anode effluent stream, said oxidant feed stream and said first portion of said anode effluent stream mixing together in said first section to form a first stage flow stream;

a second section downstream from said first section, said second section having a first main catalyst, said second section receiving said first stage flow stream from said first section and directing said first stage flow stream through said first main catalyst;

a third section downstream from said second section, said third section receiving said first stage flow stream from said second section, and a second portion of said anode effluent stream, said first stage flow stream mixing with said second portion of said anode effluent stream in said third section to form a second stage flow stream; and

a fourth section downstream from said third section, said fourth section having a second main catalyst, said fourth section receiving said second stage flow stream from said third section and directing said second stage flow stream through said second main catalyst.

2. The combustion device of claim 1, wherein said anode effluent stream and said oxidant flow stream are from a fuel cell.

3. The combustion device of claim 2, wherein said first and second portions of said anode effluent stream are an entire portion of said anode effluent stream from said fuel cell.

4. The combustion device of claim 1, further comprising at least one control valve that proportions said anode effluent stream into said first and second portions.

5. The combustion device of claim 1, further comprising at least one orifice plate that proportions said anode effluent stream into said first and second portions.

6. The combustion device of claim 1, wherein said first section further comprises a first porous foam member through which said first stage flow stream is passed, said first foam member mixing said oxidant feed stream and said first portion of said anode effluent stream together to form a generally homogenous first stage flow stream.

7. The combustion device of claim 6, wherein said third section further comprises a second porous foam member through which said first stage flow stream and said second portion of said anode effluent stream is passed, said second foam member mixing said first stage flow stream and said second portion of said anode effluent stream together to form a generally homogenous second stage flow stream.

8. The combustion device of claim 1, wherein said third section further comprises a porous foam member through which said first stage flow stream and said second portion of said anode effluent stream is passed, said foam member mixing said first stage flow stream and said second portion of said anode effluent stream together to form a generally homogenous second stage flow stream.

9. The combustion device of claim 1, further comprising a light-off section interposed between said first and second sections, said light-off section containing a light-off catalyst, said light-off section receiving said first stage flow stream from said first section and directing said first stage flow stream through said light-off catalyst and into said second section.

10. The combustion device of claim 1, further comprising a flame suppression section interposed between said second and third sections, said flame suppression section containing a flame suppression element, said flame suppression section receiving said first stage flow stream from said second section and directing said first stage flow stream through said flame suppression element and into said third section.

11. The combustion device of claim 1, further comprising a heating section interposed between said first and second sections, said heating section containing a selectively operable heating element, said heating section receiving said first stage flow stream from said first section and directing said first stage flow stream through said heating element and into said second section, and selective operation of said heating element causing said first stage flow stream to be selectively heated as said first stage flow stream passes through said electrically heated structure.

12. The combustion device of claim 11, wherein said heating element is operated during a start-up phase of the combustion device.

13. The combustion device of claim 11, wherein said heating element comprises an electrically heated catalyst and said first stage flow stream begins a catalytic reaction as said first stage flow stream passes through said electrically heated catalyst.

14. The combustion device of claim 1, wherein said oxidant feed stream and said first portion of said anode effluent stream are mixed together prior to entering said first section.

15. The combustion device of claim 14, wherein said oxidant feed stream and said first portion of said anode effluent stream are mixed together in an annular section that surrounds a portion of said first section prior to entering said first section.

16. The combustion device of claim 14, wherein said mixed oxidant feed stream and said first portion of said anode effluent stream are injected into said first section through a plurality of inlets spaced about a periphery of said first section.

17. The combustion device of claim 1, wherein said second portion of said anode effluent stream is injected into said third section through a plurality of inlets spaced about a periphery of said third section.

18. The combustion device of claim 1, further comprising a rack of generally parallel members positioned in said third section, each of said members each having a plurality of openings that communicate with said third section and directing said second portion of said anode effluent stream through said openings and into said third section.

19. The combustion device of claim 18, wherein a portion of said openings on each of said members oppose openings on an adjacent member so that said second portion of said anode effluent flow forms a fluid curtain across a cross-section of said third section.

20. A method of starting a catalytic process within a tailgas combustor with a liquid fuel until a sufficient flow of an anode effluent is available, the method comprising the steps of:

supplying a liquid fuel flow to the combustor in a quantity sufficient to meet a heat demand of a known magnitude placed on the combustor;

supplying an oxidant feed stream to the combustor;

mixing said liquid fuel and oxidant feed stream together in the combustor to form a fuel/oxidant flow;

vaporizing said fuel/oxidant flow with a heating element within the combustor as said fuel/oxidant flow passes therethrough;

reacting said vaporized fuel/oxidant flow in a primary catalyst as said vaporized fuel/oxidant flow passes through said primary catalyst so that the combustor generates heat to meet said heat demand;

exhausting said reacted fuel/oxidant flow from the combustor; and

maintaining the supplying of said liquid fuel flow to the combustor until the combustor is supplied with an anode effluent flow of a magnitude capable of allowing the combustor to meet said heat demand without said liquid fuel flow.

21. The method of claim 20, wherein said step of mixing includes passing said liquid fuel flow and said oxidant feed stream through a distribution structure that mixes said liquid fuel flow and oxidant feed stream together to form said fuel/oxidant flow as said liquid fuel flow and oxidant feed stream pass through said distribution structure.

22. The method of claim 21, further including the steps of:

- monitoring a temperature of said distribution structure to determine when said distribution structure has a temperature that is capable of vaporizing said liquid fuel flow passing through said distribution structure;
- vaporizing said liquid fuel flow in said distribution structure as said liquid fuel flow passes through said distribution structure; and
- disabling said heating element when said distribution structure is capable of vaporizing said liquid fuel flow passing through said distribution structure.

23. The method of claim 21, wherein the step of mixing includes mixing said liquid fuel flow and oxidant feed stream together in said distribution structure to form a generally homogenous fuel/oxidant flow.

24. The method of claim 20, wherein said heating element is an electrically heated catalyst and the method further includes the step of initiating a catalytic reaction of said fuel/oxidant flow with said electrically heated catalyst as said fuel/oxidant flow passes through said electrically heated catalyst.

25. The method of claim 20, further including the step of passing said fuel/oxidant flow through a light-off catalyst prior to said primary catalyst.

26. The method of claim 20, further including the steps of:
monitoring a parameter of the combustor indicative of said heat demand of a known magnitude; and
adjusting said liquid fuel flow supplied to the combustor based upon said parameter.

27. The method of claim 20, further including the steps of:
determining a quantity of anode effluent flow being supplied to the combustor; and
adjusting said liquid fuel flow supplied to the combustor based upon said determined quantity of anode effluent flow and said heat demand.

28. A method of operating a catalytic tailgas combustor to combust a flow of an anode effluent, the method comprising the steps of:

proportioning an anode effluent flow into a plurality of portions;

supplying a first portion of said anode effluent flow to a first stage of the combustor;

supplying an oxidant feed stream to said first stage of the combustor;

mixing said first portion of said anode effluent flow and said oxidant feed stream in said first stage of the combustor to form a first stage flow;

reacting said first stage flow within a first primary catalyst as said first stage flow passes through said first primary catalyst;

passing said first stage flow to a second stage of the combustor downstream of said first stage;

supplying a second portion of said anode flow to said second stage of the combustor;

mixing said second portion of said anode flow with said first stage flow within said second stage of the combustor to form a second stage flow; and

reacting said second stage flow within a second primary catalyst as said second stage flow passes through said second primary catalyst.

29. The method of claim 28, wherein said step of proportioning said anode effluent flow includes the step of proportioning said anode effluent flow between said plurality of portions so that said first stage flow formed in said first stage of the combustor has a composition that will not autoignite within said first stage of the combustor.

30. The method of claim 29, further including the step of:
measuring a temperature of said first stage of the combustor; and
wherein:

said step of proportioning said anode effluent flow includes proportioning said anode effluent flow between said plurality of portions based upon said measured temperature of said first stage.

31. The method of claim 29, wherein said step of proportioning said anode effluent flow between said plurality of portions includes proportioning said anode effluent flow between said plurality of portions so that a stage flow formed in any stage of the combustor has a composition that will not autoignite within said any stage of the combustor.

32. The method of claim 31, further including the step of measuring a temperature of each stage of the combustor, and wherein said step of proportioning said anode effluent flow includes proportioning said anode effluent flow between said plurality of portions based upon a measured temperature of an immediately preceding stage upstream from said any stage of the combustor so that a stage flow formed in said any stage of the combustor has a composition that will not autoignite within said any stage of the combustor.

33. The method of claim 28, wherein said step of proportioning said anode effluent flow includes the step of proportioning said anode effluent flow between said plurality of portions so that a stage flow formed in any stage of the combustor has a composition that will generate a sufficient amount of heat when reacted within said any stage to meet a heat demand of a known magnitude imposed on said any stage.

34. The method of claim 33, further including the step of routing a stage flow from at least one stage of the combustor through a heat exchanger to extract heat from said stage flow.

35. The method of claim 28, wherein said step of supplying said second portion includes injecting said second portion into said second stage through openings in a periphery of an interior of said second stage.

36. The method of claim 28, wherein said step of supplying said second portion includes the step of injecting said second portion into said second stage through a plurality of generally parallel members that extend across said second stage.

37. The method of claim 36, wherein said step of injecting said second portion includes injecting said second portion into said second stage through opposed openings on adjacent members.

38. The method of claim 28, wherein said step of proportioning said anode effluent flow includes the step of proportioning said anode effluent flow between said plurality of portions so that a temperature in any stage of the combustor does not exceed a predetermined magnitude for said any stage.

39. The method of claim 38, further including the step of measuring a temperature of each stage of the combustor, and wherein said step of proportioning of said anode effluent flow between said plurality of portions is based upon said measured temperature of said each stage of the combustor.